# United States Patent [19]

**Hoglund**

[11] **3,762,234**

[45] **Oct. 2, 1973**


[54] **CONTINUOUSLY ADJUSTABLE BACK LASH FREE POWER TRANSFER MECHANISM**


[76] Inventor: **Nils O. Hoglund**, Tri-Ordinate Corporation, 343 Snyder Ave., Berkeley Heights, N.J. 07922



[22] Filed: **July 20, 1972**

[21] Appl. No.: **273,627**

[52] **U.S. Cl.** ..... **74/409,** 74/425

[51] **Int. Cl.** ..... **F16h 1/16,** F16h 55/18

[58] **Field of Search** ..... 74/665 P, 409, 425



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,274,918 | 8/1918 | Maag | 74/409 |
| 3,554,044 | 1/1971 | Hoglund | 74/425 |

FOREIGN PATENTS OR APPLICATIONS

| | | | |
|---|---|---|---|
| 919,680 | 7/1949 | Germany | 74/665 P |



*Primary Examiner*—Leonard H. Gerin
*Attorney*—Dean S. Edmonds et al.



[57] **ABSTRACT**

An improved adjustment mechanism for taking up back lash producing looseness due to normal wear and tear in the gear train of a back lash free power transfer mechanism. In construction the adjustment mechanism includes a pair of coacting rotatably mounted members operatively connected to the gear train of the power transfer mechanism and arranged such that rotation of one of these members causes corresponding rotation of the other member, in turn, realigning intermeshing gear teeth of the gear train to remove back lash producing gaps or play therebetween.


**10 Claims, 4 Drawing Figures**

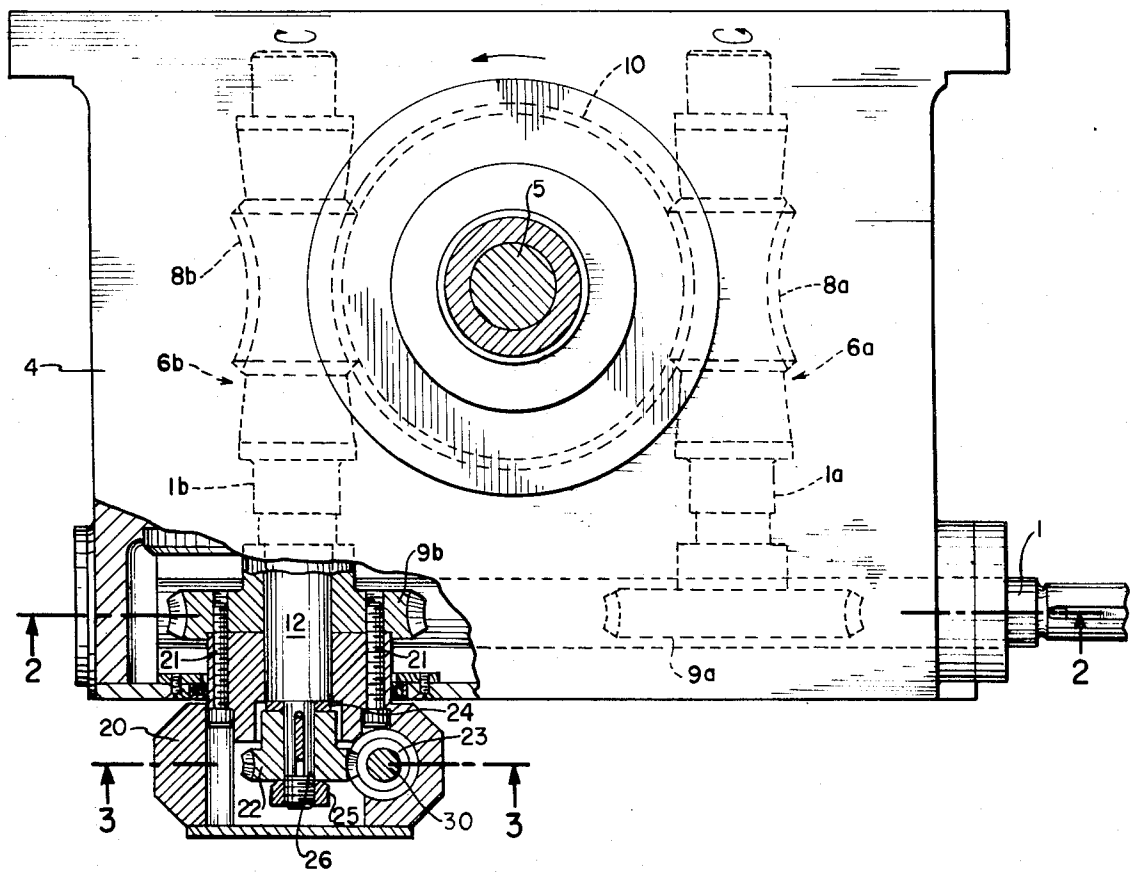
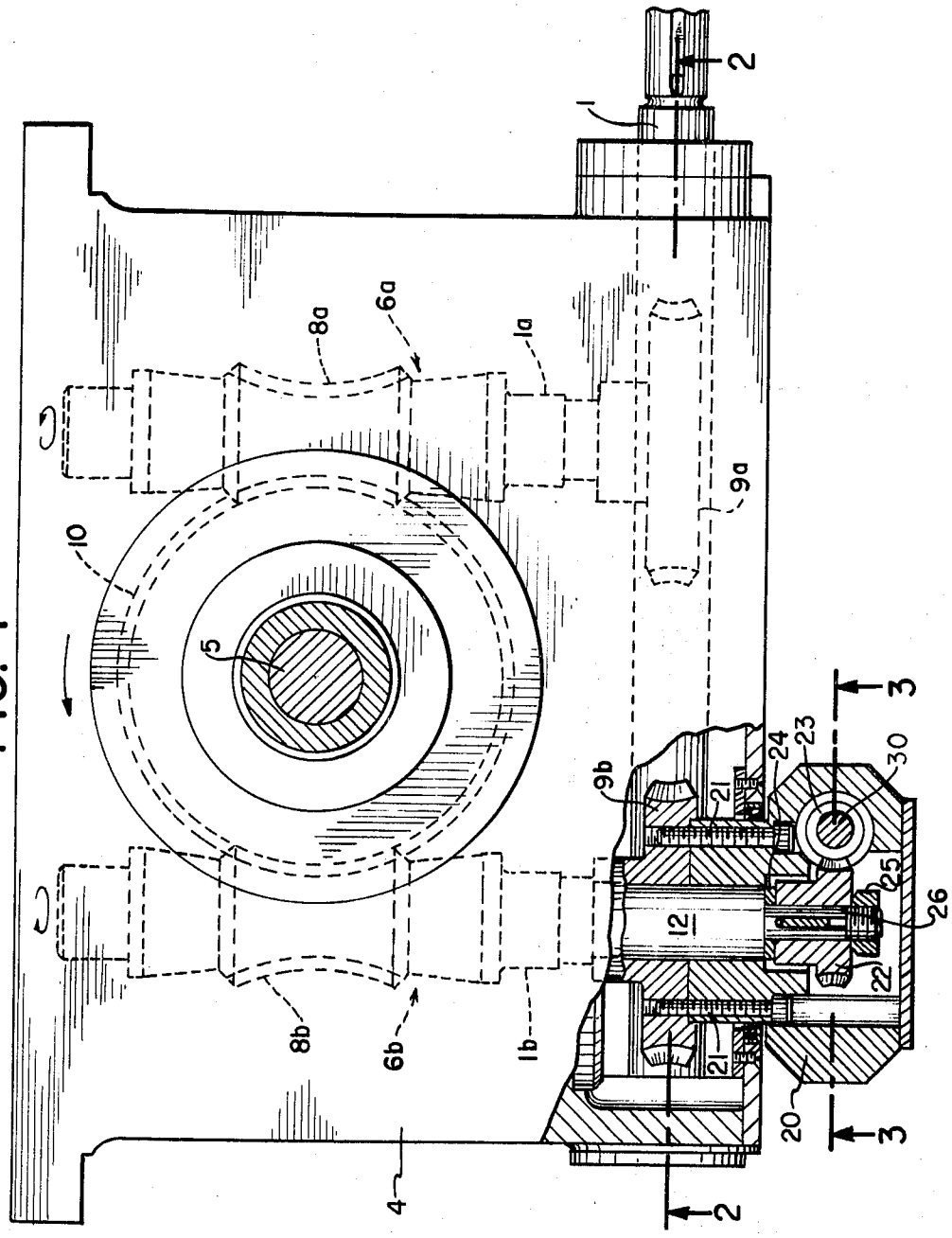


FIG. 1



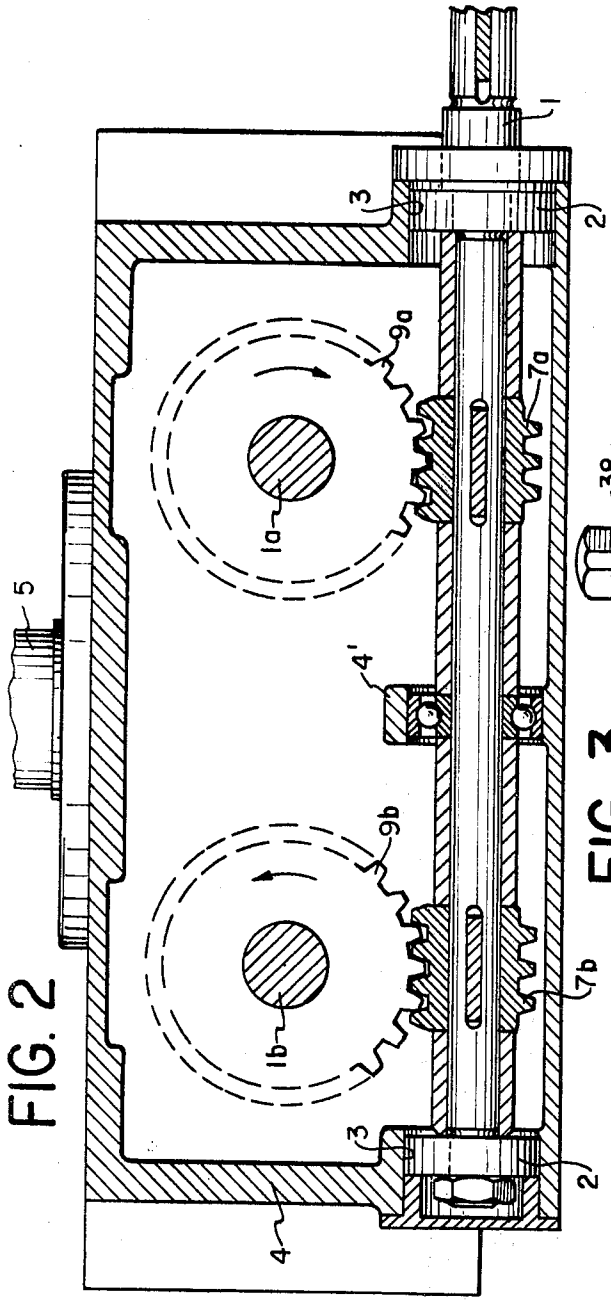

1
3
2
9a
7a
1a
5
4'
9b
7b
1b
3
2
4

FIG. 2

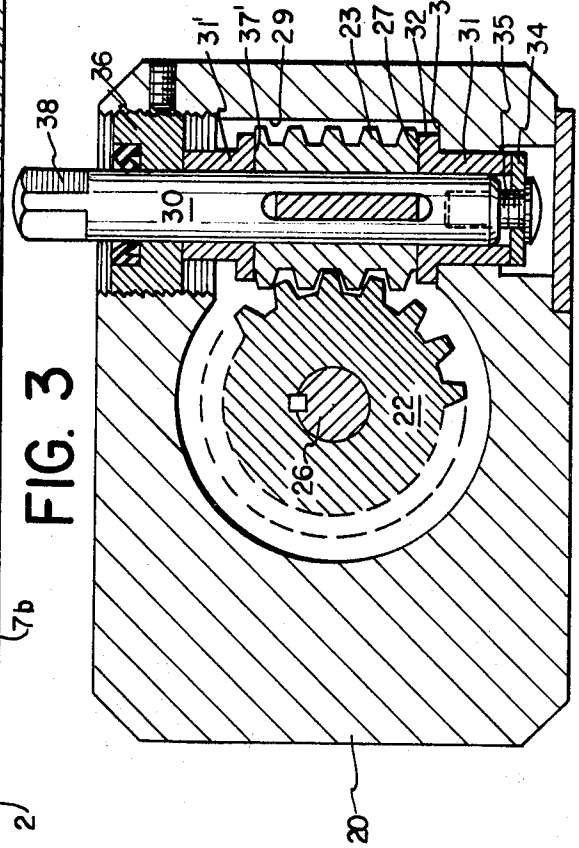

36
31'
37'
29
23
27
32
33
31
35
34
38
30
22
26
20

FIG. 3

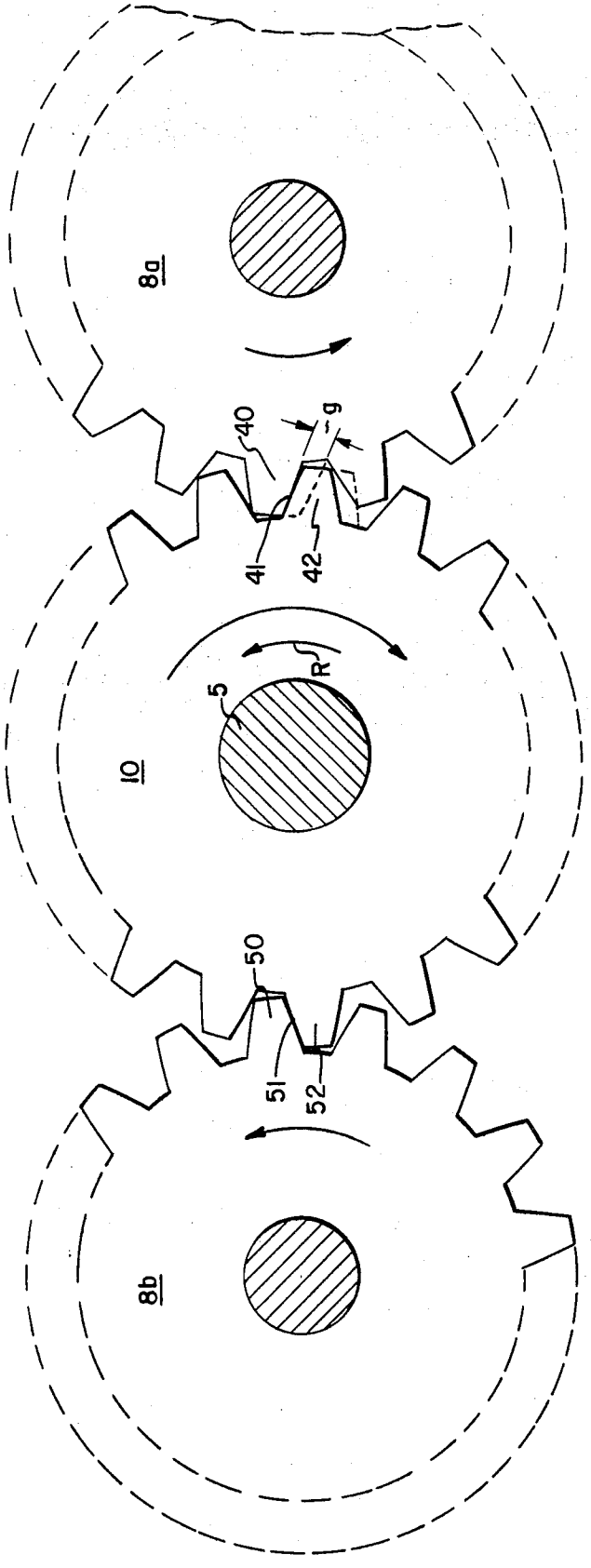



FIG. 4

# CONTINUOUSLY ADJUSTABLE BACK LASH FREE POWER TRANSFER MECHANISM

## BACKGROUND OF THE INVENTION

The transfer of power from a drive shaft to a driven cam shaft equipped with contoured cams and followers biased against the cams is often attended by the introduction of back lash into the gear train utilized to transmit power. The occurrence of back lash is particularly noticeable in applications which involve the use of sharply contoured cams. Each time the biased follower passes over a high point in the contoured cam a force is exerted by the follower on the cam shaft in the opposite direction to its direction of rotation. Upon release of this counterforce the cam shaft tends to jump or spurt forward at a rotational speed greater than the rotational speed at which it is being driven. This jumping ahead movement, in turn, creates back lash producing gaps or play between intermeshing gear teeth until such time as the play is taken up. This spurtting or jumping ahead movement also aggravates normal wear and tear on intermeshing gear teeth. In addition it can cause serious deviation in the work path of a tool or other implement which is dependent upon precision rotation of the cam shaft for proper operation.

In my U.S. Pat. No. 3,554,044 which issued on Jan. 12, 1971 a back lash free power transfer mechanism is disclosed which effectively inhibits the development of back lash producing play or gaps arising from such counterforces. Briefly, in construction, my prior patented mechanism includes a gear train which comprises a drive shaft mounting two spaced apart worm gears. These worm gears each intermesh with individual worm wheels which, in turn, are operatively connected to individual relay shafts mounting respective hourglass worm gears. The hourglass worm gears cooperatively engage opposite sides of a gear member mounted on the driven cam shaft. While each hourglass worm is driven, only one transmits power to the cam shaft through the gear member mounted thereon. The operative teeth or threads of this driving hourglass worm gear engage the rear faces of the operative teeth on the cam shaft gear member. The non-driving hourglass worm gear is positioned such that its operative teeth engage the front faces of the operative teeth or threads on the cam shaft gear member. With this construction any counterforces caused by cam followers are effectively counteracted since the cam shaft gear teeth are solidly backed up by the intermeshing teeth of the non-driving hourglass worm gear and the cam shaft gear member. Hence the tendency of the counterforce to create play between intermeshing gear teeth is effectively inhibited.

Normal wear and tear on the gearing elements of the gear train will, however, tend to result, after extended periods of use, in the development of back lash producing gaps or play between intermeshing gear teth. In order to correct this condition my prior patented mechanism includes adjustment means for realigning or rematching the intermeshing gearing elements so that such gaps are removed. For this purpose the worm wheel engaging one of the worm gears mounted on the drive shaft is mounted on its respective relay shaft for selective rotational or angular adjustment with respect thereto. This rotational adjustment is accomplished by means of a pair of set screws which engage opposite sides of a key retaining a collar to the respective relay shaft. The collar itself is removably connected to the angularly adjustable worm wheel. Upon disconnecting the collar and worm wheel, adjustment of one or the other of the set screws will cause rotation of the respective relay shaft thus effecting proper matching of the intermeshing gear teeth by what might be described as a tightening action.



While the adjustment means provided in my prior patented mechanism has many advantages, it is limited in the amount of adjustment which can be accomplished. This limitation is due to the length of the set screws which have a finite length. Thus angular adjustment or rotation of the worm wheel can only be accomplished to the extent permitted by the range of linear movement of the set screws. With a construction according to this invention my prior patented back lash free power transfer mechanism is capable of an infinite range of adjustment.

Another limitation of my prior patented mechanism is that in certain instances it is necessary to completely disassemble the mechanism both for purposes of initial matching of intermeshig gear teeth in order to obtain maximum future adjustment capability and for resetting the position of the gear teeth when the full range or adjustment provided by the set screws has been exhausted. With the construction according to this invention these drawbacks are also eliminated.

## SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, an improved adjustment means for my prior patented back lash free power transfer mechanism is provided. In construction, the adjustment means includes one housing which contains a pair of movable coacting members oe of which is mounted for movement along a predetermined path in response to movement of the other member. As presently constructed these members comprise a pair of rotatable members of circular cross section having interacting portions on their external surfaces. In particular, the members include intermeshing gears.

The first of these rotatable members of the adjusting means is mounted for rotation with a shaft together with a gearing element mounted on the shaft for selective angular adjustment with respect thereto. The housing part of the adjusting means is connected to this gearing element for rotation therewith. The second rotatable member is held against rotation about its own axis relative to the housing and the first rotatable member by selectively releasable retaining means. This second member is held against rotation in the sense that during the period when power is supplied to the mechanism it cannot rotate relative to the housing and first rotatable member. However, upon the cessation of such power and release of a retaining means, the second member can be rotated thus causing rotation of the first member and corresponding adjustment of the angular position of the shaft, to which the first member is fixed, relative to the gearing element removing back lash producing play in the gear train.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a back lash free power transfer mechanism partially in phantom to show the operative components of the gear train and partially broken away to show, in cross-section, the improved back lash adjustment means of the present invention.

FIG. 2 is a cross-sectional view taken along the lines of 2—2 in FIG. 1.

FIG. 3 is a cross-sectional view of the improved back lash adjustment means taken along the line 3—3 of FIG. 1.

FIG. 4 is a schematic diagram of intermeshing gear teeth of two gearing elements in a back lash free power transfer mechanism.

## DETAILED DESCRIPTION OF THE INVENTION

With reference to FIGS. 1 and 2, the back lash free power transfer mechanism includes a drive shaft 1 which is journaled for rotation at each end in beaing supports 2 which are seated in recesses 3 of housing 5. A third upstanding bearing support 4' is located intermediate along the length of drive shaft 1 as shown in FIG. 2. The mechanism further includes a pir of relay shafts 1*a* and 1*b* which are operatively connected between drive shaft 1 and cam shaft 5 by dual gear trains indicated generally by reference numerals 6*a* and 6*b*. Power is transmitted from drive shaft 1 to driven shaft 5 via one of the relay shafts. In the drawings the driving relay shaft is relay shaft 1*a*. For convenience and clarity in description corresponding elements of gear trains 6*a* and 6*b* will be given the same reference numeral followed by the post script *a* o *b* as appropriate.

As shown gear trains 6*a*, 6*b* include worm gears 7*a*, 7*b* mounted in spaced apart relationship on drive shaft 1 and held in place by means of conventional keys. Gear trains 6*a*, 6*b* further include a pair of gearing elements in the form of worm wheels 9*a*, 9*b* and hourglass worm gears 8*a*, 8*b*, all of which are mounted on the respective relay shafts 1*a*, 1*b*. As shown, worm wheels 9*a*, 9*b* operatively engage worm gears 7*a* and 7*b* on drive shaft 1 and hourglass worms 8*a*, 8*b* operatively engage opposite sides of gear member 10 mounted on cam shaft 5. Worm wheel 9*a* is fixedly secured to driving relay shaft 1*a* for rotation therewith in response to the power supplied by drive shaft 1. Worm wheel 9*b*, however, is mounted on the non-driving relay shaft 1*b* for selective relative rotation or angular adjustment with respect thereto.

In the construction shown, the axis of rotation of both the driving and non-driving relay shafts 1*a* and 1*b*, respectively, are disposed in perpendicular relationship with respect to both drive shaft 1 and driven cam shaft 5. Thus, in order that both relay shafts 1*a*, 1*b* are driven in a direction consistent with the rotational direction of cam shaft 5, relay shaft 1*a* and relay shaft 1*b* must be driven in opposite rotational directions. For this purpose the direction of the threading on worm gears 7*a* and 7*b* mounted on drive shaft 1 are opposite to each other. With the construction shown in the drawings worm gear 7*a* is thus provided with right-hand threads producing rotation of relay shaft 1*a* in a clockwise direction as viewed in FIG. 2. Worm gear 7*b*, on the other hand, is provided with left hand threads producing rotation of non-driving relay shaft 1*b* in a counter-clockwise direction as viewed in FIG. 2. Wtih this arrangement cam shaft 5 is driven by driving relay shaft 1*a* in a counter-clockwise direction as viewed in FIG. 1.

The manner in which back lash is inhibited by this mechanism can best be understood by reference to FIG. 4 which shows, schematically, the intermeshing teeth of cam shaft gear member 10 and the hourglass worm gears 8*a* and 8*b* disposed on opposite sides of gear member 10. As shown by solid lines in FIG. 4, hourglass worm gear 8*a* which is driving gear member 10 is positioned with its operative gear teeth 40 contacting the rear faces 41 of the operative teeth 42 of gear member 10; and hourglass worm gear 8*b* is advantageously set with its operative teeth 50 contacting the front faces 51 of the operative teeth 52 on the opposite side of gear member 10. Upon release of a counter-force exerted on the cam shaft 5 in the direction of arrow R the gear member 10 will tend to jump ahead into the position shown by dotted lines in FIG. 4 in which position it will be recognized that a back lash producing gap (*g*) exists between intermeshing gear teeth 40 and 42 of intermeshing gear member 10 and hourglass worm gear 8*a*, respectively. However, with the construction described, the gap producing jumping ahead movement of cam shaft 5 is prevented by the solid back-up action provided by contacting teeth 50 and 52 of gear member 10 and hourglass worm gear 8*b*, respectively. And, the potential aggravation of normal wear and tear between intermeshing gear teeth as the driving hourglass worm gear spurts forward to take up the gap (*g*) is substantially eliminated and consequently such potential aggravation does not contribute to looseness or play between the gearing elements of the mechanism. For a more detailed description of the back lash free power transfer mechanism reference is made to my United States patent mentioned previously.

For the purpose of removing back lash producing gaps resulting from normal wear and tear, improved adjustment means is provided. This means includes a support means in the form of a housing 20 which is secured to the face of worm wheel 9*b* by bolts 21. Contained within housing 20 are first and second coacting rotatable members 22 and 23 respectively. The external peripheral surfaces of the first and second members 22, 23 are disposed in engaging relation and are constructed with interacting portions such that movement or rotation of the second member 23 causes corresponding movement or rotation of the first member 22. In the construction shown, the interacting portions consist of a series of intermeshing gear-like teeth extending around the peripheral surfaces of coacting numbers 22, 23 which, as shown, are arranged with their axes of rotation in perpendicular relationship.

Gear-like member 22 is mounted for rotation with relay shaft 1*b*. For this purpose gear-like member 22 is keyed to shaft extension 12 of relay shaft 1*b* and separated from the end of relay shaft 1*b* by spacer 24. For the purpose of preventing longitudinal disengagement of gear-like member 22 from shaft extension 12, the free end of shaft extension 12 has a reduced portion 26 which is threaded for reception of retaining nut 25. Nut 25 holds gear-like member 22 in place. It will be recognized that with this construction, gear member 22 rotates with relay shaft 1*b*, the axis of rotation of gear-like member 22 being coincident with the axis of rotation of relay shaft 1*b*.

Power for driving relay shaft 1*b* is transmitted successively from the drive shaft 1 to worm gear 7*b*, worm wheel 9*b*, gear-like member 23 and finally to gear-like member 22 connected to relay shaft 1*b*. With this arrangement the various gearing elements of gear train 6*b*, including worm wheel 9*b* and gear-like member 22 of the adjustment means, rotate in unison during operation of the mechanism. However, it is also to be recog-

nized that relay shaft 1*b* and connected gear-like member 22 can be rotated independently of worm wheel 9*b* when no power is supplied by the drive shaft. It is this independent rotation capability that is used for the purpose of adjusting or initially taking up play between the gears and for removing play arising from normal wear and tear on the various gearing elements of the gear trains of the mechanism.

During normal operation of the power transfer mechanism the gear-like member 23 is acted upon by selectively operable retaining means to prevent rotational movement of gear-like member 23 relative to housing 20 and gear-like member 22. This means includes a pair of compression bearings 31 and 31', axially disposed on opposite ends of gear-like member 23. Releasable compression means are also included for applying sufficient axial force to the compression bearings to tightly bind the gear-like element 23 therebetween, thereby holding it against rotation about its own axis. As shown in FIG. 3 gear-like member 23 is keyed to shaft 30 which extends through bore 29 in housing 20. Disposed annularly about shaft 30 on either end of gear element 23 are the compression bearings 31 and 31'. The lower compression bearing 31 is provided with a flange 32 at its upper end which seats on shoulder 33 formed in the lower portion of bore 29. The lower end of shaft 30 is secured to compression bearing 31 by plate 34 in turn secured in abutting relationship to the end of compression bearing 31 by bolt 35.

The upper end of bore 29 is open and internally threaded to receive a releasable compression means defined by an externally threaded retaining member 36. This member bears against the end of compression bearing 31'. With this construction, retaining member 36 is adapted to be adjusted to apply pressure to bearing member 31 until the gear-like member 23 is tightly compressed between thrust bearing surfaces 37 and 37' formed on bearings 31 and 31', respectively. After the required adjustment is made, set screw 38 may be tightened to lock retaining member 36 in place. Advantageously set screw 38 is equipped with a milar tip in order not to damage the threads on retaining member 36. With the gear element 23 compressed tightly between compression bearings 31 and 31', considerable force will be required to rotate gearing element 23; and as a practical matter, gearing member 23 is held against rotation about its own axis during operation of the gear-trains 6*a*, 6*b* of the mechanism, as is more fully explained in the following portion of the specification wherein the operation of the improved adjustment means is described.

Operation of the adjustment means of this invention will be described first with reference to the condition when power is supplied by drive shaft 1 and then with reference to the condition under which adjustment of the back lash looseness is desired, in which condition power to drive shaft 1 is shut off.

With drive shaft 1 supplying power to the mechanism, worm gear 7*b* will cause rotation of worm wheel 9*b*. In turn, housing 20 which is connected to worm wheel 9*b* will rotate. Because gear-like member 23 is held against rotation as described above, the rotation of housing 20 will impart corresponding rotation through inter-engaging gear-like members 23 and 22 to relay shaft 1*b*. It will be recognized that the transmission of power to the relay shaft 1*b* is dependent upon the nonrotatability of gear-like member 22 through the interface of intermeshing gear-like teeth.

When it is desired to make an adjustment for back lash producing looseness or play as above described, the power to drive shaft 1 is disconnected and retaining member 36 may be loosened. To rotate gear-like member 23 a wrench or other suitable device is applied to the upper end of shaft 30 which extends externally of housing 20 through the open end of bore 29 as shown. Rotation of gear-like member 23 about its own axis will cause corresponding rotation of gear-like member 22 and connected relay shaft 1*b*. As worm wheel 9*b* is not connected directly to relay shaft 1*b* rotation of the relay shaft 1*b* takes place independently of worm wheel 9*b* which itself does not undergo rotational movement. However, the relative angular position between worm wheel 9*b* and relay shaft 1*b* is changed as a result of the independent rotation of relay shaft 1*b*.

The effect of rotation of relay shaft 1*b* is to tighten or take up any play or looseness in the gear trains 6*a*, 6*b* by rematching or realigning intermeshing gear teeth into their proper relative positions. For example, and referring again to FIG. 4, rotation of relay shaft 1*b* in a clockwise direction will reset gear teeth 50 against the front faces 51 of gear teeth 52 on gear member 10. And, continued rotation will reset the rear faces 41 of oppositely positioned gear teeth 42 on gear member 10 against gear teeth 40 of hourglass worm gear 8*a*. This tightening action will, in turn, be transmitted through relay shaft 1*a* to worm wheel 9*a* thus realigning the intermeshing gear teeth on threads of worm wheel 9*a* and worm gear 7*a* mounted on drive shaft 1, and so forth.

With the construction described above, an infinite range of back lash adjustment is provided since the gear-like member 23 may be rotated indefinitely to accomplish the desired adjustment. And, the necessity of carefully matching or rematching the various intermeshing gear teeth of the gear trains in order to allow for maximum future adjustment capability is eliminated. It is also to be noted that retaining member 36 is accessible externally of housing 20 through the open end of bore 29. Set screw is also accessible externally of housing 20 as shown. Thus with the construction described, it is no longer necessary to disassemble the entire mechanism to accomplish back lash adjustments.

I claim:

1. In a mechanism for transferring power free of back lash from a drive shaft to a driven shaft, said mechanism comprising a gear train means including a rotatable shaft, a gearing element mounted on the rotatable shaft for selective angular adjustment relative thereto, and adjustment means for changing the relative angular position of said gearing element and said rotatable shaft to take up back lash producing play in the gear train, the improvement wherein the adjustment means comprises:

a. support means mounted for rotation with said selectively adjustable gearing element;

b. a first member mounted on said support means for rotation with said rotatable shaft;

c. a second member mounted on said support means for selective movement along a predetermined path relative to said first member and said support means, said first and second members having interacting portions such that movement of said second member along said predetermined path causes rotation of the first member and a change in the an-

gular position of said rotatable shaft relative to said gearing element; and

d. selectively operable retaining means for preventing movement of the second member along said predetermined path during transmission of power from said drive shaft to the driven shaft.

**2.** The improvement according to claim **1** wherein:

a. the first and second members each comprise a rotatably mounted element of circular cross-section; and

b. the outer peripheral surface of said members are disposed in engaging relationship;

c. the movement of said second member along said predetermined path is defined by rotation of said second member about its own axis of mounting; and

d. the interacting portions of said members are disposed on said peripheral surfaces such that rotation of the second element causes corresponding rotation of the first element.

**3.** The improvement according to claim **2** wherein the axes of rotation of the first and second circular elements are disposed in perpendicular relationship.

**4.** The improvement according to claim **3** wherein said interacting portions comprise intermeshing gear-like teeth.

**5.** The improvement according to claim **2** wherein said selectively operable retaining means comprises:

a. a pair of compression bearings axially disposed on opposite ends of the second circular element in contacting relationship thereto; and

b. releasable compression means for applying sufficient axial force to said compression bearings to tightly bind the second circular element against rotation about its own axis.

**6.** The improvement according to claim **5** wherein said retaining means further includes:

a. a shaft element for mounting the second circular element fixed thereto;

b. a bore in the housing for receiving the shaft element, said bore having a shoulder at one end forming a seating surface for one of said compression bearings;

c. an adjustable retaining member disposed axially above the other of said compression bearings for axial movement within said bore into tight engagement with said other compression bearing; and

d. holding means for locking said retaining member in place against said other compression bearing.

**7.** The improvement according to claim **6** wherein:

a. the other end of said bore is open; and

b. said shaft element includes an extension piece extending externally of said housing through the open end of said bore, said shaft extension being adapted to fit a wrench or other suitable device for turning said second circular element to take-up back lash producing play upon release of said retaining means.

**8.** The improvement according to claim **7** wherein the axes of rotation of the first and second circular elements are disposed in perpendicular relationship.

**9.** The improvement according to claim **8** wherein:

a. said interacting portions comprise intermeshing gear-like teeth; and

b. said retaining member comprises a nut element threadedly disposed within said bore, said nut element being accessible for adjustment externally of said housing through the open end of said bore.

**10.** The improvement according to claim **9** wherein said holding means comprises a set screw adapted to engage said nut element, said set screw being accessible for adjustment externally of said housing.

* * * * *

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,762,234 Dated October 2, 1973

Inventor(s) Nils O. Hoglund

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Abstract, line 4, "mechanism" should read --mechanism is disclosed--.

Column 1, line 58, "gear teth" should read--gear teeth--.

Column 2, line 35, "oe of" should read --one of--.

Column 3, line 14, "beaing" should read --bearing--;

line 15, "housing 5" should read --housing 4--;

line 18, "pir" should read --pair--; and

line 27, "a o b" should read --(a) or (b)--.

Signed and sealed this 14th day of May 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.